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(FOR ARTICLES ON THE GEOLOGY OF EAST ANGLIA)

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CONTENTS INCLUDE

Geological Heritage of Banham, South Norfolk

Geomorphology of Dersingham Bog, West Norfolk

Iron Pan Sediments in West Norfolk

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EDITORIAL

This issue of the Bulletin concentrates on the geology of the south and west of the county of Norfolk. Larkin and Hoare make the interesting connection between geology and historical local industry in the Banham area. They also locate and describe a tunnel in a former brickearth pit that exposes part of the Banham Beds and the Lowestoft Till. Stevenson and Giles describe the geomorphology of the Dersingham area, and make the case for the presence of cryoplanation terraces formed under periglacial conditions. In the last article, Stevenson reviews new locations of West Norfolk iron pan sediment which historically has been used locally as a building stone.

Thank you to reviewers

It is 11 years since I formally thanked reviewers for the work they put in on behalf of authors and the editor. The following have given excellent advice: if I have omitted names, then I apologize in advance as I value the contributions of all reviewers.
Prof T. Atkinson, Dr P. Allen, Dr J. Bacon, Dr V. Bense, Prof. D Bridgland, Dr N. Chroston, Dr W. Christensen, Prof J. Hancock, Prof J. Hart, Prof K. Hiscock, Dr P. Hoare, Prof M. Leeder, Dr R. Markham, Dr N. Monks, Dr J. Radley, Prof. J. Rose, Mr P. Riches, Dr J. Turner, Prof A. Watts, Dr C. Wood, Dr M. Woods, Dr C. Whiteman, Dr M. Whiteman and Mr P. Whittlesea,

INSTRUCTIONS TO AUTHORS

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It is important that the style of the paper, in terms of overall format, capitalisation, punctuation etc. conforms as strictly as possible to that used in Vol. 53 of the Bulletin. Titles and first order headings should be capitalised, centred and in bold print. Second order headings should be centred, bold and lower case. Text should be 1½ line spaced. All measurements should be given in metric units.

References should be arranged alphabetically in the following style.

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STEERS, J.A. 1960. Physiography and evolution: the physiography and evolution of Scolt Head Island. In: Steers, J.D. (ed.) *Scolt Head Island* (2nd ed.), 12-66, Heffer, Cambridge.

BLACK, R.M. 1988. *The Elements of Palaeontology*. 2nd Ed., Cambridge University Press, Cambridge. 404pp.

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The editors welcome original research papers, notes, comments, discussion, and review articles relevant to the geology of **East Anglia** as a whole, and do not restrict consideration to articles covering Norfolk alone. All papers are independently refereed by at least one reviewer.

THE GEOLOGICAL HERITAGE OF BANHAM, SOUTH NORFOLK: CIDER, BRICKS AND TUNNEL VISION

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ABSTRACT

The Chalk bedrock, Quaternary sediments and soils of the Banham district of south Norfolk had a profound influence on its industrial and social wellbeing for hundreds of years. The settlement's pivotal role in the development of cider in Norfolk, which dates from the early thirteenth century, was due largely to the rich loamy soils. Lime burning and gravel extraction were common, and the availability of clay-rich deposits of glacial origin led to the manufacture of bricks (which may be traced back to the eighteenth century) and to related kiln-based industries such as tile, drainpipe, chimney and cider flagon making.

Geological sections are few and far between in this relatively flat and low-lying landscape. But when worked-out nineteenth-century brickearth pits at Hunt's Corner, immediately west of Banham, were transformed in ca 1914 into the ornamental 'Garden of Eden,' a 'Tunnel of Love' was excavated through a baulk between two of the pits; the tunnel now provides a rare opportunity to examine the glacially related fluviatile and lacustrine Banham Beds and the Lowestoft Till dating from the Middle Pleistocene Anglian Stage (Marine Isotope Stage 12). A brief description of the exposures of this important part of Norfolk's rich Quaternary geological archive is given here.

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INTRODUCTION

The geology and industries of Banham

The part played by geology

The bedrock, superficial geology and soils of the large parish of Banham in south Norfolk (National Grid Reference TM 0688; Fig. 1) have had an inordinate influence on its commercial and social wellbeing for several centuries. Norfolk may be regarded as the cradle of English cider-making, and Banham's pivotal position in its development stretches back to before 1281 (see below). Soil is an important factor in cider production since it "...materially affects the apple-juice and its keeping properties, more especially for export purposes..." (Stopes, 1888, 22; see also Anon., 1969). The town's widespread reputation for expertly made bricks is due in no small part to its clay-rich deposits of glacial origin that are "... eminently adapted for the purpose" (Kelly, 1865, 175). The geology of the area was put to many other uses, as evidenced by place names such as Chalk Pit, Banham Limekilns, Limekiln Farm, Gravel Pit and Gravelpit Lane found within a small area of 1:10 560 scale Ordnance Survey sheet XCV. S.E. (1884).

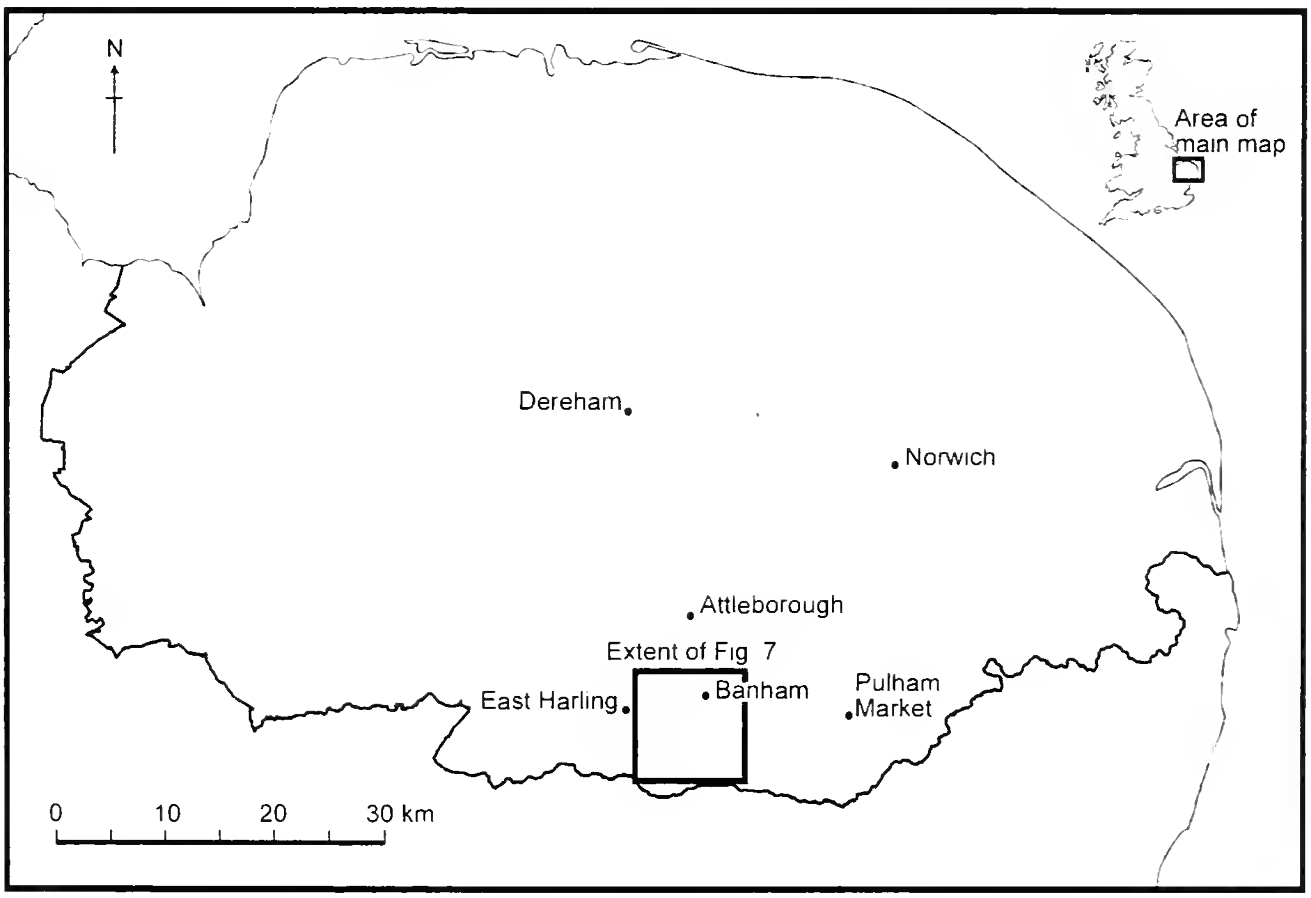


Fig. 1. The location of places mentioned in the text.

Whilst brick and cider manufacture brought wealth to Banham in the nineteenth century, there was also considerable poverty. The population in 1841 was 1166, a decrease of 131 over a ten-year period, caused in large measure by 250 of its poor being sent to Lower Canada (parts of the modern-day provinces of Quebec, Newfoundland and Labrador) in 1835 (Anon., 1844, 201).

Cider making began in Norfolk on a very modest scale as early as 1205 (Anon., 1935). It is recorded in the Banham manorial rolls that in 1281 the lord of the manor had "... Apple Orchards (pomeria) ... reckoned at three casks of Cyder (dolia cysarici) price of a cask 10/- ..." (Norfolk Archaeological Records cited in Anon., 1935). It is likely that Banham "... has had a cider industry, as distinct from a local reputation for cider-making, for at least 300 years", and it may lay claim to being England's oldest cider village (Anon., 1956). It was said that "... the finest Cider is made, not in the West, but in the East, of England" (Stopes, 1888, 20). Throughout the nineteenth century Banham's rich loamy land was at the centre of the county's cider-making industry.

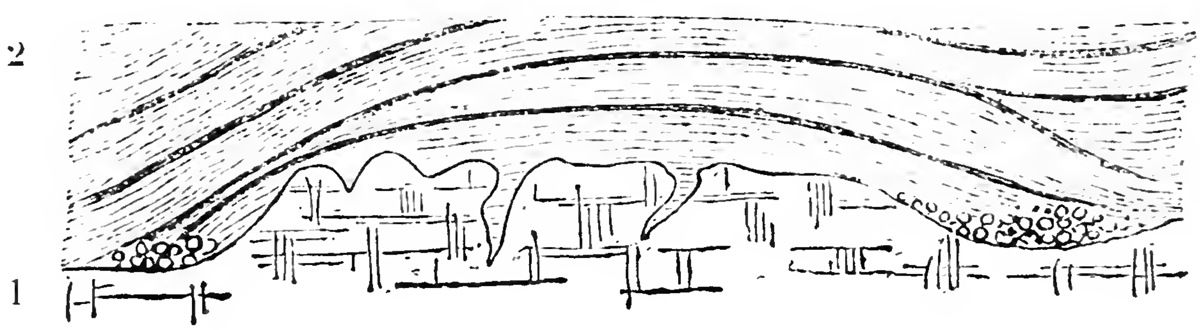
Gaymer's, the pre-eminent cider manufacturer in Banham, started production towards the close of the seventeenth century (Kelly, 1883, 237; White, 1883a, 136). William Gaymer transferred his business to Attleborough (TM 0495) in 1896 (Anon., 1935, 1936; see also Stopes, 1888, 21–26), and the company lost its independence in 1961 (Anon., 1961) (see also Thompson, 2007, 6–9). Rout's were established in Banham in 1856 (see, for example, White, 1883b, 19) and ceased trading in *ca* 1959 (Anon., 1969; see also Thompson, 2007, 9–10). A number of small cider producers were still active in and around Banham in the late 1960s (Anon., 1969; Thompson, 2007, 10).

Brickmaking has also enjoyed a lengthy history in Banham. A 'post-medieval' brick kiln is shown at TM 058875 on Faden's (1797) map of Norfolk; and William Agnew was manufacturing bricks and tiles as late as 1916 (Anon., 1916, 42). Two brickyards were of particular importance in the nineteenth century, Ludkin & Son and Hunt. A manufactory of superior bricks, tiles and chimney-pots located about three-quarters of a mile (*ca* 1.2 km) south of the town was described as "... the most extensive in the county ..." (Anon., 1846, 1165). About 150 people were employed in making bricks and tiles in Banham in 1845, at a time when the population of the parish was 1165 (White, 1845, 421). The local raw material was also used to fabricate cider flagons and drain-pipes.

Bennett (1884, 5–6) described two facies of 'brickearth or loam' within the Quaternary succession of the Banham area, both more or less laminated: a brown 'sandy clay' (giving rise to red bricks) and a stiff blue 'clay' (producing white bricks) (Fig. 2); they were said to be best developed between Banham and East Harling (TL 9986). At Banham, the brickearth was worked principally "... at the brickyard west of the church ..." (Bennett, 1884, 7), a location that may have been that which was to become *The Garden of Eden* (see below). The only other detailed survey of the superficial deposits of the area is that by Mathers, Zalasiewicz, Bloodworth & Morton (1987).

Prince Albert, Queen Victoria's consort, asked that Banham bricks should be used in the construction of model cottages "... which he showed in an exhibition" (Anon., 1978). It is probable that this was the Great Exhibition of 1851 held at the Crystal Palace (undated note in Norfolk Museums & Archaeology Service record GRSRM : CP.CP693 by Bridget Yates, former curator). The cottages were constructed from hollow bricks manufactured using Whitehead's apparatus (White, 1854, 756–757). The Revd S.F. Surtees, parish priest at Banham, purchased one of these machines at the Great Exhibition, and a handsome school was constructed with the bricks which had a "... beautiful white and stone-like appearance" (White, 1854, 756–757).

Section at the Banham brick-kiln.



2. Brown and grey clay, roughly stratified and resting in hollows in the Chalk, which are lined at the junction with thin brown clay, like the clay-with-flints. Pockets of fine, quartzose, pebbly gravel also occur here and there at the base of the clay; the gravel in places is highly ferruginous. The total thickness of these beds is about 15 feet.
1. Rubbly Chalk.

Fig. 2. Section in Quaternary sediments at an exposure adjacent to the Banham brick-kiln; total thickness is *ca* 4.6 m (Bennett, 1884, fig. 2).

Celebration of the former industries

Brickmaking and cider production are commemorated in the village sign (Fig. 3), in the William Gaymer (d. 22 May 1936: see Anon., 1936) stained-glass window in the church of St Mary the Virgin (Thompson, 2007, 2), in 'stones' engraved with the initials 'W.G.' (William Gaymer) and 'F.R.R.' (Frederick Richard Rout) in the red brick walls of local buildings (Thompson, 2007, 11) and in the name of *The Brickmakers Arms* public house (no longer in business). The collections at *Gressenhall Farm and Workhouse Museum of Norfolk Life*, *ca* 5 km northwest of Dereham, Norfolk (TF 9616), include examples of Rout's cider bottles, numerous specimens of Banham tiles, pipes, bricks and brick moulds and photographs of workers in the village's brick pits.

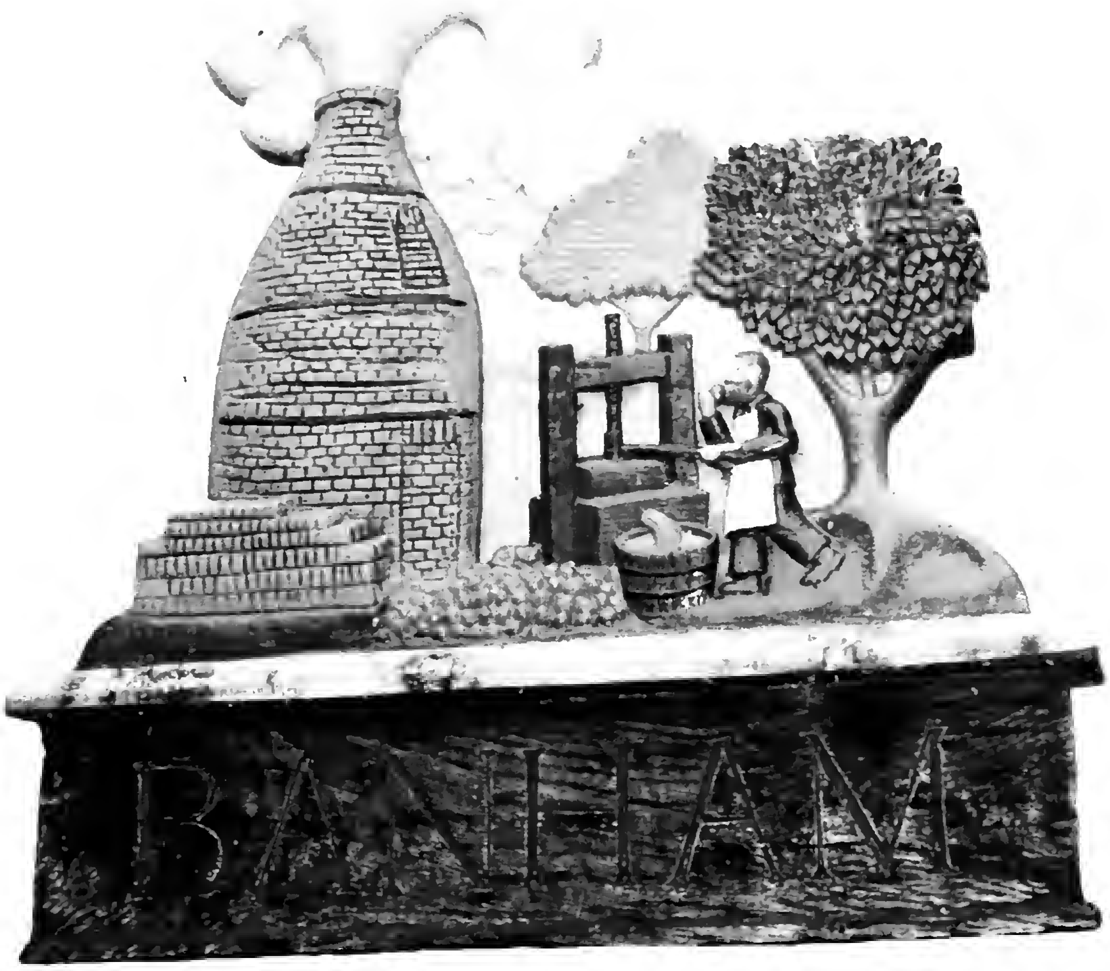


Fig. 3. The Banham village sign, erected *ca* mid-1970s, illustrates a working brick kiln, a 'pile' or 'clamp' of 'green' bricks, an apple tree and apples being pressed to make cider (Anon., 1978). (P.G. Hoare, July 2010.)

THE GARDEN OF EDEN

Frederick Richard Rout, proprietor of the *Eden Cider* brand, transformed seven acres (2.8 hectares) (Anon., 1933, 44) of the family's orchards in former brick pits at Hunt's Corner, Banham, into ornamental pleasure gardens in *ca* 1914 (Pollitt, 1992) (TM 05568815; Norfolk Historic Environment Record [NHER] 15985). This, *The Garden of Eden* (Fig. 7), was opened to the public in aid of the Norfolk and Norwich Hospital, the Red Cross and other charities, and became a major tourist attraction during the 1920s and 1930s (Court, 1982b; Tyzack, 2006). It was "... beautifully and originally laid out ..." and included an aviary (Anon., 1933, 44), fruit trees and shrubs and a dovecote (Court, 1982b). Entrance to *The Garden of Eden* cost 3d (1p); visitors were charged an additional 1d to walk through the candlelit 'Tunnel of Love' (Tyzack, 2006). The gardens became so popular that in the 1920s Rout built a Lutyens-style property, also known as *The Garden of Eden*, from which he sold teas, fruit, vegetables, flowers and postcards (Court, 1982b, c; Pollitt, 1992; Webster, 1995; Tyzack, 2006; NHER 15985). The building also functioned as a public house (Anon., 1989). Court (1982b) reproduced two postcards of *The Garden of Eden* dating from the period when they were open to the public; Pollitt (1992) included a contemporary view of the grounds.

The Garden of Eden also contained a great many curiosities. Amongst these oddities were a First World War German field gun (Court, 1982a, b), a stone bell-tower from the old Banham Grammar School (Court, 1982a; Webster, 1995) and fragments of the *ca* 84 m-long Italian-built SR1 Pulham Market-based airship (a 'Pulham Pig') that was used as garden trellis and incorporated into two bridges (Anon., 1982, 1989; Court, 1982a, b, 1989). Rout subsequently converted the property into his home where he lived until his death in 1939 (Webster, 1995). *The Garden of Eden* was sold by auction at Attleborough on 29 June 1939 (Court, 1982c; Webster, 1995).

The 'Tunnel of Love'

The 'Tunnel of Love' was dug through a natural baulk that separated two abandoned brickearth pits. It describes an open S-shape in plan, is oriented approximately east–west, is 35 m long, *ca* 1 m wide and has an average height of *ca* 2 m. The passageway was brick-lined and the roof was reinforced with an iron structure (since removed). The top of the tunnel lies less than 2 m below the natural ground surface which is at

ca 45 m O.D. A branching passage close to one end, and a neighbouring (possibly very short) tunnel, are blocked and their original extent is unknown. Local legend held that the tunnel was used to dry bricks when the pits were active (NHER 15985), and Pollitt (1992) referred to it as a former clay store. The 'Tunnel of Love' was, in fact, a folly and part of the Rout development (NHER 15985). Less romantically, the bill of sale of 1939 referred to a "... deep (*sic*) tunnel ... [which] forms a safe bomb-proof shelter ..." (Court, 1982c).

The house and grounds of *The Garden of Eden* have had a chequered history. There have been various phases of restoration (see, for example, Court, 1982a, Pollitt, 1992 and Webster, 1995), but the property had been neglected for some time when it was purchased by the McNerney family in 2007. The tunnel is once again in a reasonable state of repair, although the roof has collapsed along two short sections giving rise to an undulating floor. It can be negotiated throughout its length with the assistance of artificial light, save for the period between September and April when Brown (or common) long-eared (*Plecotus auritus*), Daubenton's (*Myotis daubentonii*) and Natterer's bats (*Myotis nattereri*) hibernate there (Martin Horlock, personal communication, December 2009).

The greater part of the tunnel's sides are still lined with clay bricks of various styles, ages and colours (including red, white, grey and brown); more recent repairs have been carried out using breeze blocks. Some parts of the tunnel are lined with large 'bricks' that appear to have been fashioned out of Chalk-rich till. Quaternary deposits are seen in restricted exposures where the brick lining has fallen or where no lining ever existed.

Since exposures of superficial deposits are now uncommon in this low-lying district, and permanent sections such as those in the 'Tunnel of Love' are exceedingly rare, the opportunity was taken to prepare a brief account of these sediments.

THE 'TUNNEL OF LOVE' EXPOSURES

Tunnel vision The superficial deposits may be seen principally in two places in the walls and adjacent roof of the 'Tunnel of Love'. Exposure 1 (Fig. 4) occurs intermittently between 8.5 m and 12.0 m from the eastern end of the passageway; exposure 2 (Fig. 5) lies *ca* 12 m from the western end of the tunnel and is 2.22 m long. The Quaternary succession is difficult to establish in view of the limited extent of the faces and the highly irregular nature of the geological boundaries (*cf.* Fig. 2),

but may be resolved into beds A and B that rest on a highly irregular Chalk surface in exposure 1.

Fig. 4. Exposure 1. Bed A, represented here by a brown, weathered, very sandy deposit with small flint clasts, part of the Banham Beds sequence, rests on an irregular Chalk bedrock surface. Scale in centimetres.

Fig. 5. Exposure 2. Detail of Bed B resting on a highly irregular Chalk bedrock surface at the western end of the 'Tunnel of Love', high up on the northern side. Bed B displays involutions formed under periglacial conditions; solution is likely to have modified the surface of the Chalk; ?iron-enriched layers pick out contortions in the Chalk caused by periglacial processes. Scale in centimetres.

Field and laboratory methods The tunnel exposures were described, sampled (it was not possible to collect sufficient material to represent the gravel [>2.00 mm] fraction) and photographed. The field-state colour of the deposits was determined using *Munsell Soil Color Charts.* Particle-size distributions were established by disaggregating subsamples in 0.5 % (w:v) sodium hexametaphosphate solution and examining the suspension with a Beckman/Coulter laser-diffraction particle-size analyser. Representative subsamples of the matrix (<2.00 mm fraction) were ground with a pestle and mortar and the calcium carbonate-equivalent content measured in a Bascomb Calcimeter (Gale & Hoare, 2011, 266–269). It must be borne in mind that the original colour, carbonate content and texture of the sediments have inevitably been modified as a result of their permeability and near-surface position.

A permanent exposure of the Anglian Banham Beds ('North Sea Drift')

Exposure 1

Bed A (samples GE3 and GE4) is a massive, dark grayish brown (10YR 4/2) to pale yellow (5Y 7/3), slightly calcareous (mean calcium carbonate-equivalent content 0.74 and 0.18 % [n = 3] respectively), almost clast-free, sandy silt or silty sand (*sensu* Folk, 1954); it is moderately fresh but displays mottles and rootlet traces indicative of weathering.

The superincumbent bed B (samples GE1 and GE2) is a brownish yellow (10YR 6/8) to pale yellow (2.5Y 8/4) diamicton which is >0.8–0.9 m thick (top of bed not seen); flint clasts up to *ca* 90 mm in length occur. Bed B consists of two distinct facies. One, represented by sample GE1, is only slightly calcareous (mean calcium carbonate-equivalent content 3.99 % [n = 3]). The other (sample GE2) has a carbonate content close to 100 %; it is evidently reworked Chalk or simply a glacially transported mass of bedrock. GE1, a silty sand, is thought to have been derived from mud-rich GE2-type material by weathering. Flint gravels (*ca* 65–70 mm in observable length) are preserved at the junction of beds A and B.

Exposure 2

Bed B is also seen at exposure 2 where considerable selective post-depositional periglacial modification and some decalcification are apparent. Type 1, 2 and 3 involutions (*sensu* Murton, Bateman, Baker, Knox & Whiteman, 2003, 222) account (in part) for the highly irregular contact between the Chalk and bed B; the effect of frost disturbance on the upper part of the bedrock is shown by the complex disposition of redeposited iron-rich material. Such involutions appear to be common in the vicinity of Banham (Fig. 6); they also closely resemble chalkland periglacial features in Kent and Sussex (Julian Murton, personal communication, 21 September 2010). The form of the drift/bedrock contact in the 'Tunnel of Love' is also likely to have been influenced by solution at the Chalk surface.

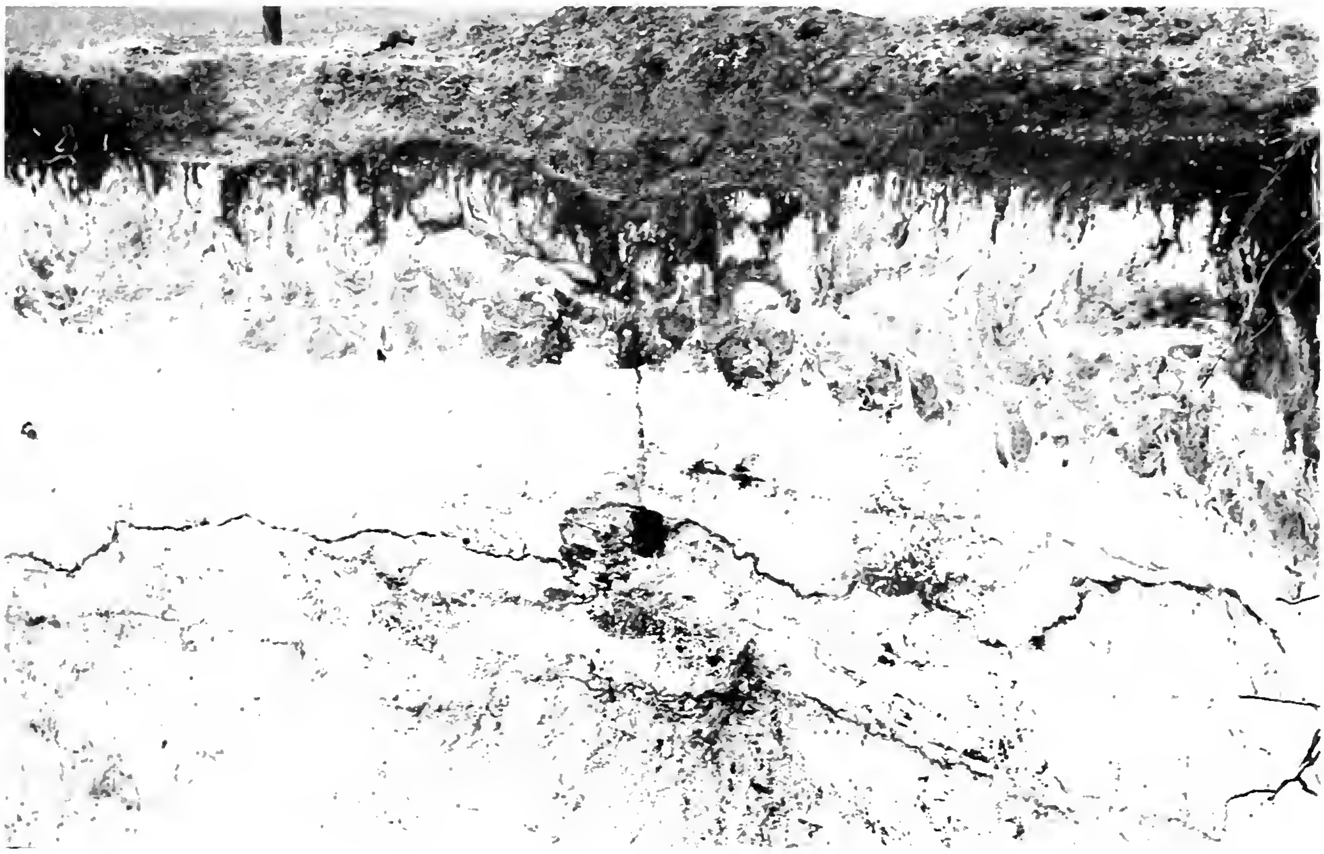


Fig. 6. A former vertical exposure near East Harling (TL 9986), *ca* 6.5 km from *The Garden of Eden* reveals another example of the complex junction between Chalk bedrock and overlying drift. The highly irregular dark contact is probably solutional in nature (Julian Murton, personal communication, 21 September 2010). The photograph was taken in 1936 by Hallam Ashley F.R.G.S. (Norfolk Museums & Archaeology Service record NWHCM : 2004.3.297).

DISCUSSION

Drawing principally on the work of Bennett (1884) and Mathers *et al.* (1987), bed A is interpreted as a component part of the Banham Beds succession. This extremely variable sequence is generally 5–10 m thick but may reach 15 m in depressions in the Chalk bedrock surface (Bennett, 1884, 5, fig. 2; Mathers *et al.*, 1987, 231). The Banham Beds are preserved as a relatively high-level erosional remnant at between 30 and 40 m O.D., which crops out on the flanks of tributaries of the River Wittle in the Banham–Kenninghall–Quidenham area (Mathers *et al.*, 1987, 231) (Fig. 7). Mathers *et al.* (1987, 239) concluded, somewhat tentatively, that the Banham Beds are largely glacially related, fluviatile and lacustrine sediments that accumulated close to the margin of the Anglian (Marine Isotope Stage 12) 'North Sea Drift' ice sheet (= Happisburgh Formation?).

The term North Sea Drift Formation (Mathers *et al.*, 1987, 229; Gibbard, 1999) was coined to reflect the belief then prevalent that these sediments were deposited by ice that advanced from Scandinavia. More recently, Lee, Rose, Riding, Moorlock & Hamblin (2002) established that they were laid down by a north British ice sheet; but calls for the abandonment of the epithet 'North Sea' had begun even before this paper was published (see, for example, Hamblin, Moorlock & Rose, 2001, 17).

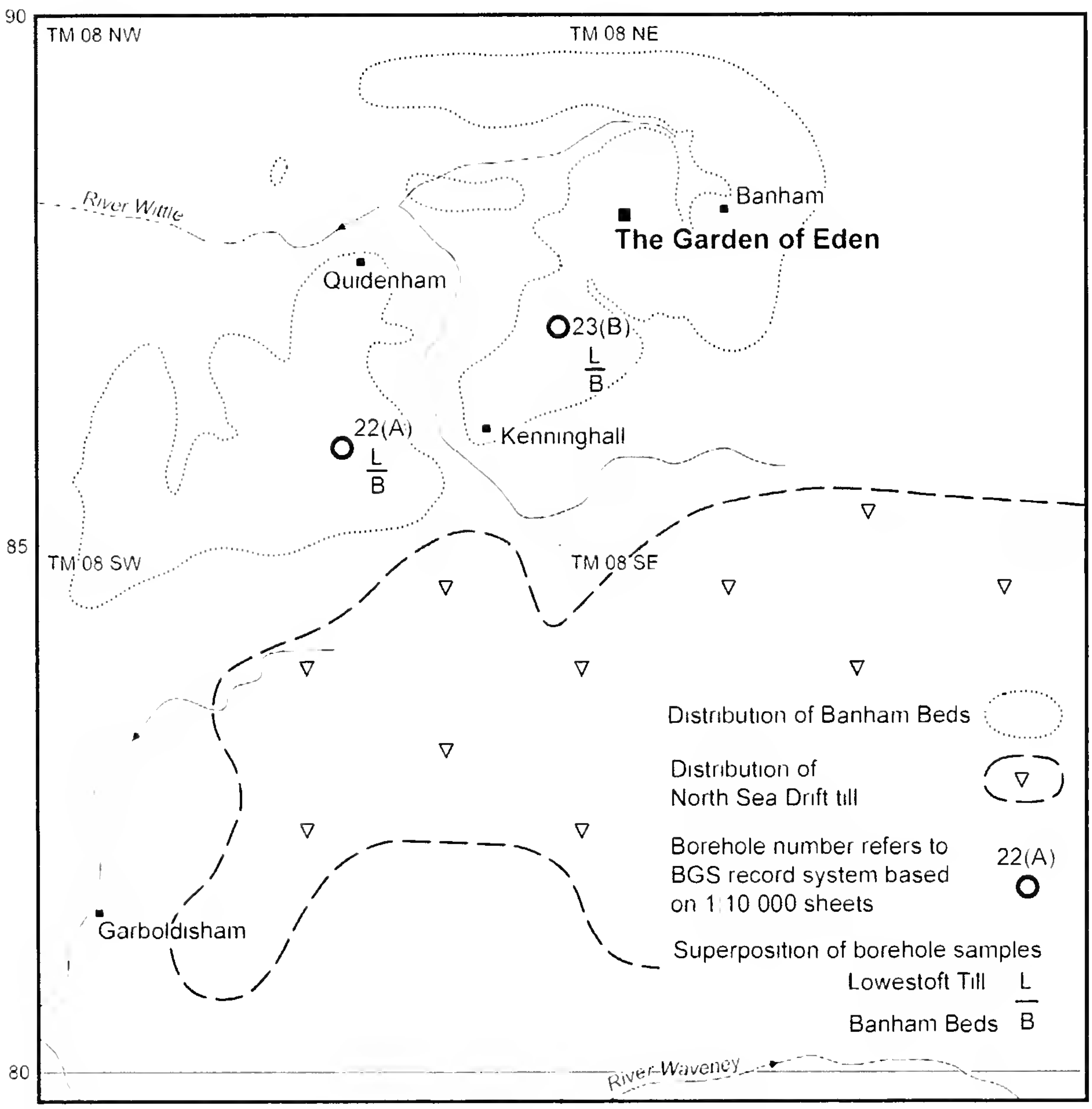


Fig. 7. The distribution of the Banham Beds and 'North Sea Drift' till in the Banham–Redgrave area, together with the position of boreholes referred to in the text (after Mathers *et al.*, 1987, fig. 2); the location of *The Garden of Eden* is also shown. Lowestoft Till overlies the Banham Beds in borehole 23(B) (TM 04948701), *ca* 1.2 km southwest of *The Garden of Eden*.

A number of tills are known from the Banham area with which bed B might be compared. A 2.4 m thick, grey, pebbly sandy clay, said to be a lodgement till, was recorded within the type Banham Beds sequence in borehole TM 08 NW 22, *ca* 3.5 km southwest of the 'Tunnel of Love' (TM 02888590) (Mathers *et al.*, 1987, 231, 233, 239, figs 2–4). Correlation of bed B with this till may be rejected with some confidence as the Banham Beds are characterised by an "... almost total absence of Chalk" (Mathers *et al.*, 1987, 234). The 'North Sea Drift' till outcrop lies no closer than *ca* 3 km to the south of the 'Tunnel of Love'. Bed B is not unlike Lowestoft Till and its highly calcareous facies known as Marly Drift. Significantly, Lowestoft Till overlies the Banham Beds in borehole 23(B) (TM 04948701), a mere *ca* 1.2 km southwest of *The Garden of Eden* (Mathers *et al.*, 1987, figs 2, 4). The particle-size distribution of sample GE2 from bed B (the less weathered of the two samples collected) plots close to the envelope for Lowestoft Till (n = 9) in Mathers *et al.* (1987, fig. 6a), lending further weight to the proposed correlation (Fig. 8). Note also that Bennett (1884, 13) recorded 3–10 feet (0.9–3.0 m) of 'White Boulder Clay' (= ?Marly Drift/Lowestoft Till) overlying very coarse gravel half a mile (0.8 km) northwest of Banham church (*ca* TM 057887) and *ca* 550 m north of *The Garden of Eden*.

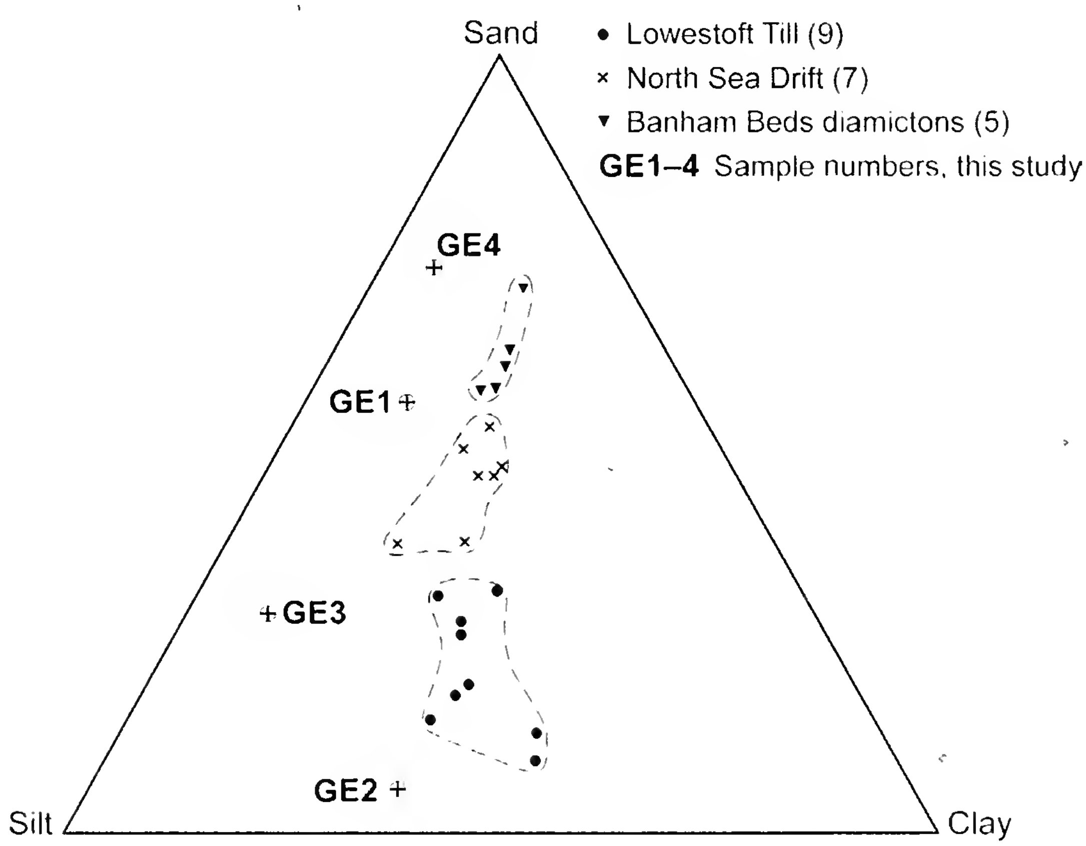


Fig. 8. The particle-size distribution of tills and diamictons from the Banham Beds examined by Mathers *et al.* (1987) and of samples collected from the 'Tunnel of Love' exposures, Banham, Norfolk (this paper).

CONCLUSIONS

The geological resources of the Banham district have been very successfully exploited in a number of ways, particularly in connection with the production of cider, bricks and related products, for a great deal of time. The 'Tunnel of Love' sections, although limited in extent, reveal part of the Banham Beds sequence and the Lowestoft Till, and they offer a more or less permanent and accessible opportunity to examine a critical part of Norfolk's rich Quaternary geological archive (note that in order to visit the exposures written permission must be obtained, and that access is not permitted during the winter months). Inland sections such as this are few and far between. Whilst excellent coastal exposures of related sediments exist, they are subject to rapid weathering, slumping and erosion.

ACKNOWLEDGEMENTS

Thanks are due to Bryan McNerney and his family for allowing us to examine the 'Tunnel of Love' exposures, for furnishing historical information and for their hospitality; to David Gurney and Hazel White of Norfolk Landscape Archaeology for providing access to files on Hunt's Corner, Banham Brickworks and *The Garden of Eden*; to Martin Horlock of Norfolk Biodiversity Information Service for details of hibernating bats; to Dr Julian Murton for advice on the periglacial features exposed in the 'Tunnel of Love'; to staff at the Millennium Library and the Norfolk Record Office, both in Norwich; to Simon Dobinson, Laboratory Manager, Geography Department, Queen Mary University of London, for help with the particle-size analyses; and to Edward Oliver, Cartographer, Geography Department, Queen Mary University of London for drawing Figures 1, 7 and 8.

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The Geological Society of Norfolk (GSN) website can be found at:

http://www.norfolkgeology.co.uk

The contents and abstracts of the Bulletins, starting in 1953, are all available for download on the website. Many back issues are available in print form, see p. 38.

The society also has a Facebook page and an Earth Science Database containing over a thousand articles relevant to the geology of Norfolk.

THE GEOMORPHOLOGY OF THE DERSINGHAM BOG NATIONAL NATURE RESERVE, WEST NORFOLK

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ABSTRACT
It is suggested here that the 'cliffs' at Dersingham originated in pre-Devensian times and that their present form has resulted from periglacial processes rather than from coastal erosion during a former marine highstand. The prominent flat surface above the scarp faces may be a cryoplanation terrace. This terrace is possibly partly concealed by coversands containing ventificated material.

INTRODUCTION

The Dersingham Bog National Nature Reserve (NNR) is situated some 7 km NNE of King's Lynn in north-west Norfolk (Fig. 1). It is primarily designated as a NNR on the basis of its plant communities, which include large areas of dry *Calluna* heath and a wet acid mire, or bog. It is part of the Sandringham Royal Estate and is marked as Sandringham Warren on some maps.

The most prominent physical feature of the Dersingham Bog NNR is a north-west facing escarpment, which overlooks the mire itself (Figs 2 & 3). It extends (roughly) from TF670283 in the south to TF680293 in the north, and forms part of an outcrop of Lower Cretaceous rocks which extends north-south through west Norfolk, from Hunstanton southward, and which – it has been claimed – represents an ancient shoreline formed when the sea broke through into the Wash in Quaternary times (Gallois, 1994, p 153.). The area is shown on BGS sheet 145 (BGS 1978). The slopes seen in the NNR are steeper than those seen elsewhere along the outcrop and this has been attributed to relatively recent marine erosion.

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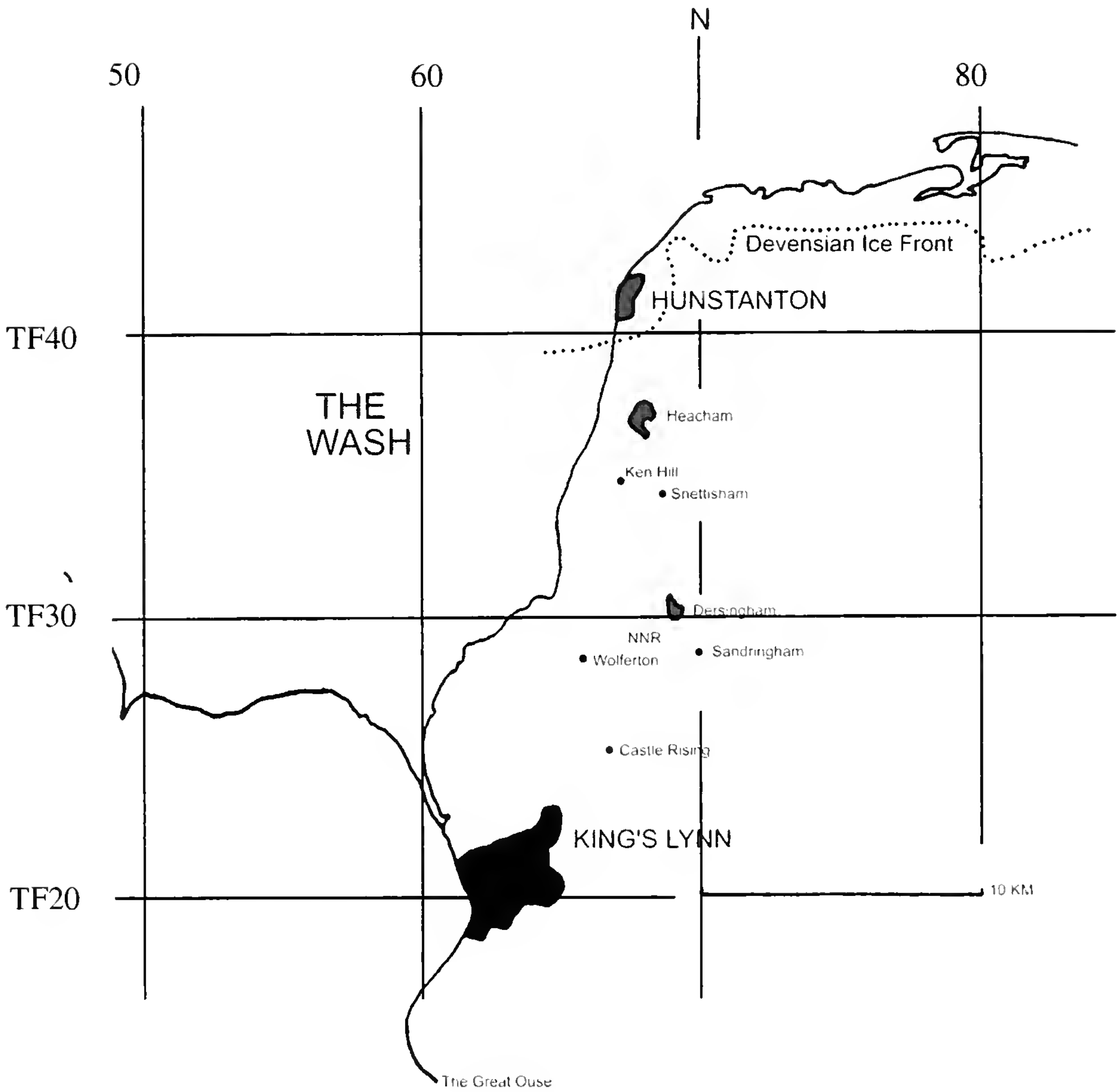

Fig. 1. The location of Dersingham Bog NNR. The marginal figures are those of the 10 km grid squares of the British National (Ordnance Survey) Grid. The Devensian ice front is indicated by the dotted line.

The scarp is made up of Lower Cretaceous sands and is topped by a marked flat bench feature of variable width, the origin of which appears to have been ignored. The A149 runs NNE-SSW across this; to the east of the main road the ground rises again, in a second scarp, where harder rocks (the Carstone) crop out (Figs 2 & 3).

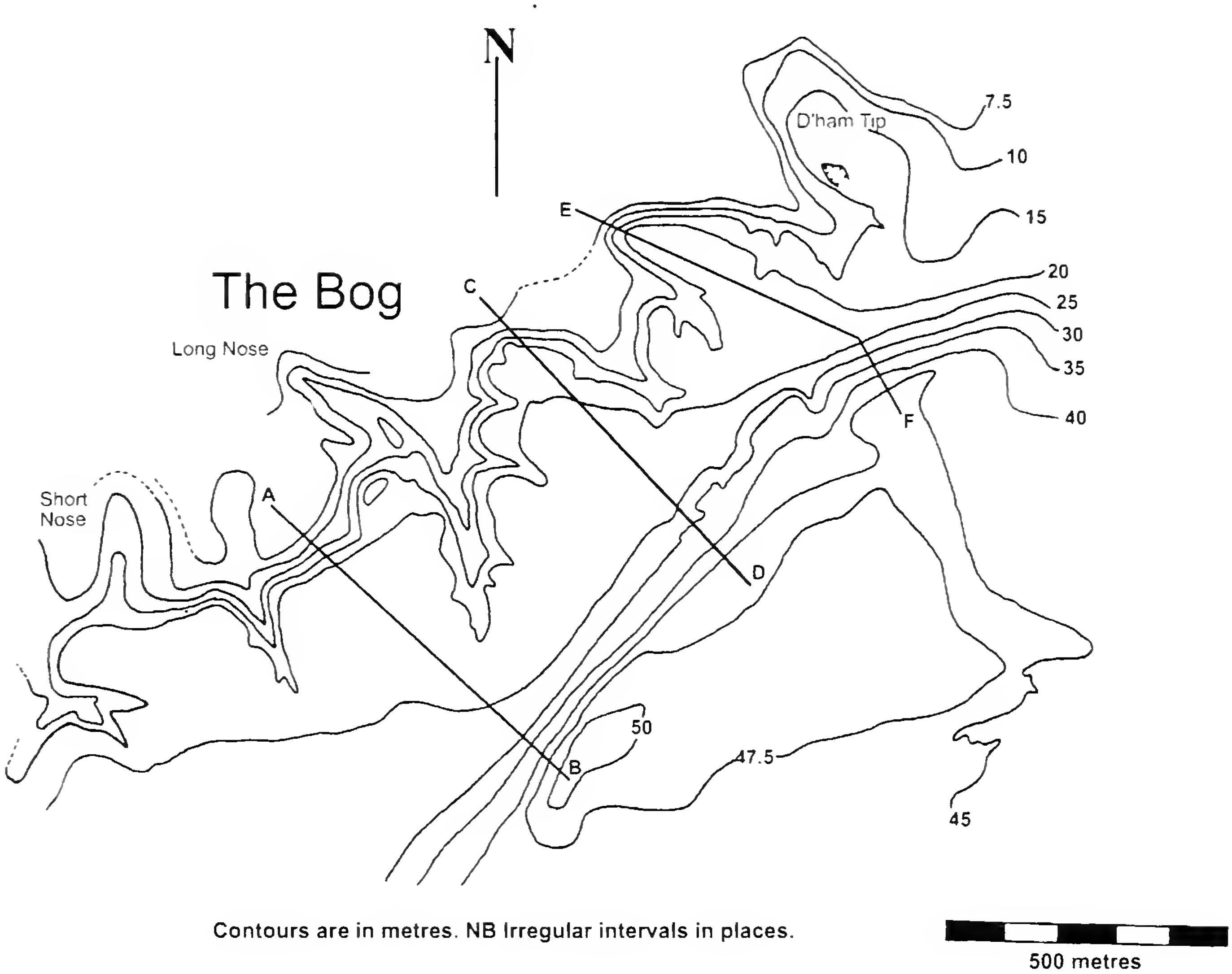

Fig. 2. Contour map of the area, based on an orienteering map prepared by the Cambridge University Orienteering Club (1980). Contours are at 2.5 m intervals. The section lines A-B, C-D, and E-F are illustrated in Fig. 5. The names Short and Long Nose are used on site but are not official. The promontory at the northern end is the site of the old Dersingham village tip and so consists largely of made ground.

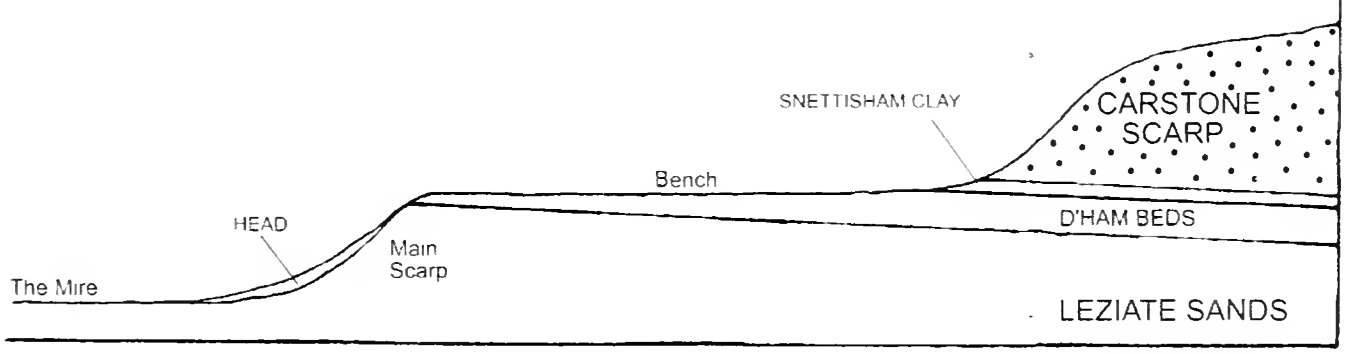

Fig. 3. A schematic cross-section through the site, roughly along the line A-B in Fig.2 which is NW (left) to SE (right) orientation. Not to scale.

Popular local mythology has it that these 'sea cliffs' formed during the last deglaciation, about 7000 years ago as sea-level recovered to its present position; indeed Natural England has an explanatory sign in the NNR claiming just this. The sign is located adjacent to a very impressive 'cliff', which is actually part of a railway cutting; they suggest that this is what the rest of the escarpment may have looked like 6000 years ago. Gallois (1994), however, states that the escarpment is probably a Pleistocene feature, cut *prior* to deposition of the Devensian Hunstanton Till, i.e. well before 20,000 years ago. What is certain is that the present morphology of the scarp owes little to marine erosion processes.

PRE-QUATERNARY GEOLOGY OF THE AREA

The pre-quaternary geology of the area is simple: all of the local bedrocks dip gently NE, although the general regional dip is eastward (Fig. 3).

The oldest beds exposed are the Lower Cretaceous Leziate Sands, which form the upper part of the Sandringham Sands Formation; these are relatively pure fine-grained quartz sands which, except in the vicinity of Castle Rising, are unlithified, and therefore highly susceptible to erosion.

Above them lie the Dersingham Beds which, in some horizons, are much better cemented and therefore more resistant to erosion. They consist of fine-grained iron cemented flagstones interbedded with soft brown and white sands (Gallois, 1994, p.83). The Dersingham Beds cap the flat upper surface of the scarp. They are overlain by the Snettisham Clay which, though not exposed, acts as an aquitard for water percolating through the overlaying Carstone, resulting in a spring line. The Carstone, which is generally a coarser-grained iron-cemented sandstone, is only exposed outside the NNR, on the Sandringham Royal Estate. Further east outcrops of Red Chalk and Chalk are present.

THE QUATERNARY GEOLOGY OF THE AREA

This area was affected by Anglian ice (Charlesworth 1957), which may have played some part in sub-glacially shaping the present scarps, the softer Jurassic clays that crop out to the west being more easily eroded, and the more resistant Cretaceous strata forming higher ground.

Table 1. Relevant stages of the Pleistocene and their relationship to marine isotope stages (MIS) after McMillan, Hamblin & Merritt (2005).

British Stages	**European Stage**	**MIS**	**Climate**
Holocene/Flandrian	Flandrian	MIS 1-2	Temperate
Devensian	Weichselian	MIS 2 – 5a–d	Cold
Ipswichian	Eemian	MIS 5e	Temperate
Wolstonian	Saalian	MIS 6-10	Cold
Hoxnian	Holsteinian	MIS 11	Temperate
Anglian	Elsterian	MIS 12	Cold

A variety of other processes will also have affected the landscape during the intervening interglacials and cold periods; opinions differ over the position (and MIS, Table 1) of putative ice margins during the Wolstonian Cold Stage (Gibbard *et al.* 2009; White *et al.* 2010; Langford 2012); however, the present landforms probably originated largely from the most recent (Devensian) Cold Stage processes and subsequent Holocene events.

The Devensian ice limit lay only a short distance to the north (see Britice map www.sheffield.ac.uk/geography/staff/clark_chris/britice), so the whole area would have been affected by periglacial conditions. The northern fringes of the area may also have been influenced by lacustrine processes operating in Lake Fenland – a body of fresh water trapped between the Devensian ice front and higher ground to the south, east and west (Britice www.sheffield.ac.uk/geography/staff/clark_chris/britice).

THE LANDFORMS

a) The scarp faces: The softest rocks in the area, the Leziate Sands, form the major portion of some of the steepest slopes in the area; however, the steepness of the scarp varies considerably. Given that the Leziate Sands in the area are remarkably uniform lithologically (Gallois 1994 p.74) this cannot be accounted for by variations in lithology. In general, however, the slope is best described as having a concavo-convex profile, with the concavity at the base. As Gallois (*op cit.* p.153) notes, this basal portion of the slope is directly underlain by head deposits that extend outwards under the surface of the present mire.

Recent temporary sections created at the northernmost part of the scarp, as a result of conifer clearance prior to heathland re-creation, show that the upper two or three metres of the scarp is capped by Dersingham Beds, whilst the whole surface of the scarp is covered, to a depth of a metre or so, by grey podolised sandy soils that cover bedrock.

b) The flat scarp top bench: The conifer clearance referred to above has produced extensive views across the upper surface of the scarp faces showing how remarkably flat this surface is (Figs 4 and 5). The surface is reduced to a series of more-or-less separate units by stream erosion (Fig. 2) but presumably it must originally have formed a single bench, continuous for nearly two kilometres.

The bench corresponds with the outcrop of the upper part of the Dersingham Beds. It varies considerably in width, but can be quite extensive – extending outwards for up to 500 m (Fig. 5). It also varies slightly in height, being rather lower at the northern end (at between 20.0 m and 22.5 m), and higher (between 27.5 m and 30.0 m) in the south; this slope is almost certainly due to the control exerted by the regional dip of the Dersingham Beds, with which it is parallel.

Fig. 4. View looking towards the scarp from TF670284 showing the steep scarp face ('cliff') surmounted by a flat bench surface.

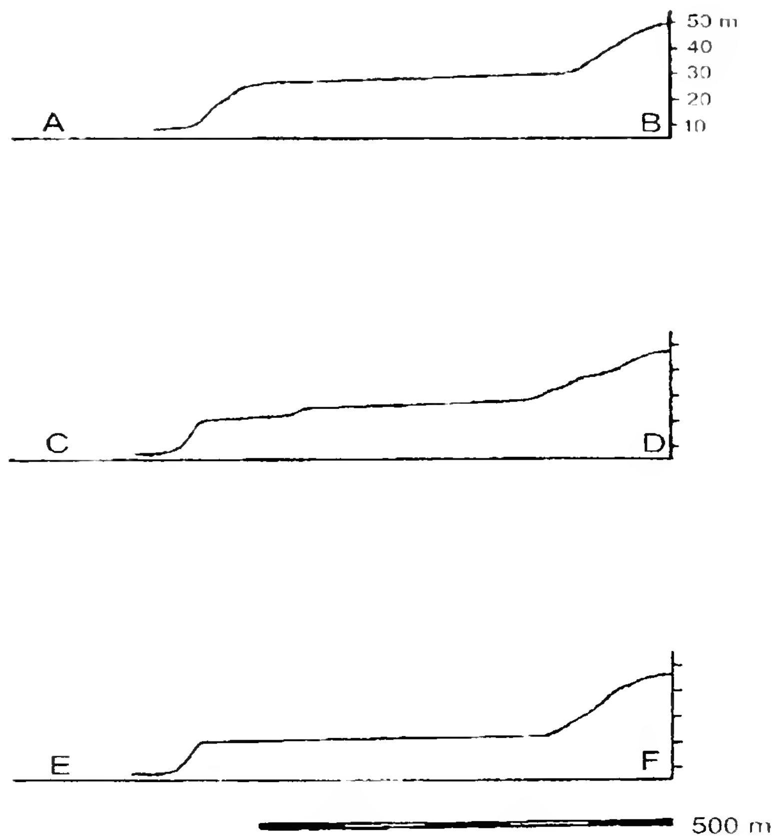

Fig. 5. Cross-sections across the benches. The position of the lines of section are shown on Fig. 2 and are broadly in NW (left) to SE (right) orientation. (Vertical exaggeration = x4)

The surface is not completely flat: in places there are roughly parallel lines of very shallow (drainage?) furrows (e.g. the area around TF671281) which were probably created during afforestation of the benches. There are also various other depressions, some of which are clearly man-made, where pits have been dug into the Dersingham Beds to win stone for local use (e.g. around TF676288). Slope angles vary very slightly across the benches (Fig. 5).

It is curious that the scarp/bench edge does not appear to have been influenced by gullying, something which is normally common at the top of soft sediment cliffs. Presumably this is because the underlying rocks are so permeable that, under normal circumstances, surface flow does not occur on such gentle slopes (see Fig. 3).

In places the bench surfaces display a scattering of flints and fragments of both Carstone and Dersingham Bed; clasts of Red Chalk, vein quartz and other exotic lithologies occur rather more sparingly. An interesting question is when, and by what process, were these clasts introduced onto the benches and what is their provenance?

c) The valleys: There are a number of valleys that cut into the scarp, dissecting the bench surface into distinct blocks (Fig. 2). They all start near the top of the Dersingham Beds where they abut the overlying Snettisham Clays (see Fig. 3). The latter has clearly acted as an aquitard, generating springline streams which presumably became active in post-glacial times, even though they are effectively dry at present.

The fact that these valleys cut through the bench surface suggests that it was present *before* active stream erosion started. Since there is little or no direct evidence of fluvial action forming the benches their origin must be sought elsewhere.

DISCUSSION OF LANDFORM GENESIS

a) The scarp faces: The evidence for either modern or cold climate processes of marine erosion (Trenhaile 1997) having played any great part in the formation of these 'cliffs' can be evaluated:

- Given that the rocks (and their disposition) are similar along the whole west Norfolk coast, why are steep cliff-like slopes not present everywhere? Steep slopes do occur further north, in the area of Ken Hill (TF670339) where they are associated with the outcrop of the Carstone, but elsewhere slopes are generally fairly subdued.
- Although the geology of the scarp is remarkably consistent there is considerable variation in slope angle, and the steepest slopes are not necessarily in positions where one might have expected wave action to have been most intense at a time of higher sea levels, leading to undercutting and steepening. Indeed, in places steep slopes are present in positions where they should have been protected from major wave action by adjacent topography. (The present coast lies some 2.5 km to the west; the intervening ground consists of marsh deposits, indicating a long history of coastal progradation).
- In places, promontories such as Short Nose and Long Nose (see Fig. 2), protrude into the mire. They are composed of Leziate Sand, which would have been vulnerable to even gentle wave attack.
- A common feature of soft sediment cliffs (as on the north Norfolk coast) is the presence of rotational slips, triggered either by undercutting or lubrication of impervious layers by water penetrating downwards from the cliff top. There is

no evidence of these anywhere in the area. Nor is there any evidence of gullying at the scarp edge.

- There is an absence of shoreline deposits such as dunes or shingle beaches at the foot of the 'cliffs'. However, being soft sediment structures, these may have been destroyed by subsequent mass-wasting processes. (The Geological Survey map of the area (BGS, 1978) shows extensive slope (head) deposits at the foot of the scarp, beyond which lies marine alluvium (the Terrington Beds) whilst, at a distance of 1 km+ seawards, glacial sand and gravel deposits are indicated).
- The head deposits at the base of the scarp consist largely of sandy materials derived from the Leziate Sands, as well as abundant fragments of Dersingham Beds material, and flint.

All of these points are enough to indicate that these landforms, as suggested by Gallois (*op cit.* p.153), are of much greater age that the recent deglaciation. However, that leaves the question of when and how they were modified to their present form, and their relationship to other processes, particularly those occurring in Devensian times.

The precise limits of ice penetration during the Devensian are uncertain; the BRITICE map shows the consensus opinion at present and all interpretations show the ice margin lying north of the area under consideration.

South of the Devensian ice limit there was a large proglacial lake – Lake Fenland. The Britice map (Britice: www.sheffield.ac.uk/geography/staff/clark_chris/britice; Clark *et al.* 2004) shows the putative margins. These margins, however, have been extrapolated from published data, using a digital evaluation model, and other interpretations have been offered (e.g. Straw 1979; Cameron *et al.* 1992; Jones & Keen 1993). While none of these maps are sufficiently precise to exactly locate where the lake shore lay, it is reasonable to suggest it coincided with what is now higher ground. The Britice map indicates that one of these areas of higher ground was the area of this study.

In a periglacial setting, waves generated by katabatic and other winds would have been likely on Lake Fenland. The predominant winds blowing off the Devensian ice sheet are likely to have been northerly or north-westerly ones. Wave fronts would thus have been normal to these winds, albeit modified by local meteorology and topography. Under these circumstances it is logical to infer that

wave eroded features, or evidence of wave erosion in general, would show an orientation related to the prevailing wind (and subsequent wave) directions. Although a variety of landforms are associated with the margins of periglacial lakes (Ballantyne & Harris 1994; French 2007) there are no extant features in the area which can be directly attributed to lacustrine erosion, although they could be buried under head deposits and sediment derived from the valleys.

As there is little or no evidence for water, either marine or lacustrine, playing a significant role in the shaping of these scarps, mass movement thus becomes the likely candidate mechanism. Certainly, the presence of abundant fragments of Dersingham Beds lithologies on lower slopes, such as Long Nose, suggests that downslope movements were occurring locally. As Tricart (1970 p.135) observes, in sands with little cohesion slopes behave similarly to scree slopes and remain steep. Such mass movements were, presumably, more liable to occur under periglacial conditions when the role of vegetation in stabilising surfaces would have been, at best, minimal.

b) The flat scarp top bench: As noted above, a thin patchy veneer of pebbles exists in places on the terrace surface. Some of the flint clasts show a characteristic gloss patination, or waxy sheen, which occurs elsewhere in the area where flints are enclosed within coversands containing undoubted ventifacts (Hoare *et al*., 2002). The patination process probably takes thousands of years and results from silica dissolution through corrosion by wind driven particles, and by exposure to UV, all of which would have acted on sub-aerially exposed clasts (Howard 1999, 2002; Burroni 2002). Some of the Cartsone clasts also have a shiny 'desert varnish' type surface, and show patterns of etching consistent with wind erosion. It seems most likely that the wind etching and polishing occurred *in situ*, and that the accompanying sands are coversands, potentially extending northwards the distribution described by Hoare *et al*. (2002). However, the disturbance to the sediments caused by tree removal, make it virtually impossible to prove them to be purely aeolian in origin.

The fact that some of the clasts present show signs of having been influenced by (presumably) periglacial wind action suggests that they were either present before, or were brought in at the same time as, strong wind action was taking place.

Fig. 6. Sand-wedge exposed at TF6792529228, cutting down into a fine sandy facies of the Dersingham Beds. These features occur in areas where strong winds are available to blow sand into thermal contraction features (Ballantyne & Harris 1994). (Spatula handle is 12 cm.)

The origin of this material is problematic. Whilst the flints are mainly angular and subangular, suggesting fairly short distances of travel and/or local frost shattering, the 'exotic' quartz and sandstone clasts are uniformly well-rounded, suggesting the sand cover was thin and impersistent. However, the surface of the terraces has been so much disturbed that this latter observation cannot be regarded as too significant. Clast-rich surfaces also occur (in places) on some of the lower slopes where they are underlain by Leziate Sands. Further evidence of peiglaciation is a sand-wedge, revealed in a temporary section on the scarp edge (Fig. 6).

The absence of any significant sediment cover on the bench suggests it is dominantly erosional in origin. Whilst it is possible that it could have been carved by Anglian ice, it is highly improbable that it could have survived intact during the intervening glacial and interglacial episodes, given the range of active erosional processes operating over such long time intervals. Equally improbable is an origin as a marine or lacustrine wave-cut platform: the consensus opinion is that neither sea levels nor pro-glacial lake levels were ever as high as 30 m above mean sea level,

except in the Hoxnian, when they may have been as high as 25 m above datum (see Jones & Keen (1993) for a discussion of Pleistocene sea level changes). Even if this terrace had formed in Hoxnian times, apart from the high likelihood of destruction during subsequent periods, the absence of any beach materials, and the fact that the terrace slopes towards the north do not support such an origin.

It is, of course, possible that the bench formed at a lower elevation and owes its present position to isostatic readjustment, in which case it *might* have been formed by marine or lacustrine processes. However, this would demand that the steep scarp face should either have been present as a subaqueous feature or have formed subsequent to the fall in water levels. Both scenarios seem inherently unlikely.

In the absence of any other simple explanations for the origin of these very flat surfaces, their morphology is consistent with the possibility of their being cryoplanation (or nivation) terraces (French 2007).

Cryoplanation terraces can be cut into all types of bedrock though they tend to be best developed in fine-grained closely jointed material such as the Dersingham Beds. Nivation, as a process, involves the removal of debris created by freeze-thaw activity, by mass wasting processes operating under snow banks (Reger & Péwé 1976; French 2007), these having accumulated against structural benches or where initial irregularities in slope occurred.

The steeper ground to the east, associated with the 'harder' Carstone, would have facilitated the formation of snow banks, whilst the lithology of the Dersingham Beds themselves – which contain high proportions of fine, unconsolidated sands – would have been very susceptible to removal by nival processes including intenstive freeze-thaw, slopewash and accelerated solifiction (Ballantyne & Harris 1994). Clearly there needed to be some sort of bench present in the first instance, on which snow could accumulate and bank up against the Carstone.

Presumably the pre-Devensian hydrology would not have been dissimilar to that of today, so the Snettisham Beds would have acted then, as now, as a spring line. Localised spring sapping could then have created a topography against which at least some snow banks accumulated, thus initiating a more pronounced episode of sub-nival erosion. The possibility that the terraces could have been formed entirely by this latter process, in pre-Devensian times, can be discounted: any extensive water flows would have cut deeply into the underlying beds, creating valleys such as those seen today. Of such valleys there is no sign.

The width and extent of these features indicates that, if they were formed by nival processes, then they are cryoplanation terraces, rather than nivation benches which tend to be rather smaller; however, the two differ only in size and maturity of development (Ballantyne & Harris 1994). These features can be hundreds of metres wide and kilometres long, with downslope angles on the treads of between 1° and 14°, and with treads that characteristically meet the backslope with a sharp break of slope (Priesnitz 1988). The terraces associated with the Dersingham Beds are within the dimensional range quoted, as are the slope angles. There is also a sharp break of slope at the back (Fig. 5).

Cryoplanation terraces are postulated to be associated with areas that have experienced severe periglacial climates (Reger & Péwé 1976) and the presence of a sand wedge confirms this, whilst the presence of ventificated material, although not conclusive, offers supporting evidence.

The processes involved in cryoplanation terrace creation are poorly understood, and some authors (e.g. Thorn & Hall 1980) have suggested, because the alleged mechanisms of formation would be so slow, that they must – in part – be derived from pre-existing erosional or structural features. Hall & André (2009) failed to find any evidence of freeze-thaw weathering, and an absence of any evidence of debris transport in Antarctic examples of cryoplanation terraces, even though these are the dominant mechanisms alleged to be involved in their formation.

This combination of circumstances makes them difficult to recognise with certainty. Convincing examples in the UK are described from Devon (Guilcher 1950; Gerrard 1988) but further north examples are equivocal. According to Ballantyne & Harris (1994) research into cryoturbation landforms in Britain so far has been 'site-specific and speculative'; we intend to conform to those norms, whilst taking comfort from the fact that they also note that 'On present evidence, convincing cryoplanation phenomena occur only in southern England beyond the limits of maximum glaciation' and hinting that these features may have developed over very long timescales throughout the Pleistocene.

French (2007 p. 244) suggests that the concept of cryoplanation is going out of flavour (at least in Russia) and that many previously identified terraces are primarily controlled by lithology – as appears to be the case here. Despite reservations French (*op cit* p. 245) considers that 'the cryoplanation concept is still a useful working model' to explain landscape evolution under periglacial conditions.

The formation of the terrace would obviously precede the thermal contraction cracking, subsequently giving rise to sand wedges, due to movement of sand across it, which also resulted in ventification of some materials. Coversands elsewhere in the area (Hoare *et al.*, 2002) have been dated to the late Devensian Loch Lomond Stadial (12,800 – 11,500 BP); coversands on the terrace are probably of similar age.

The surface debris of flint and other materials, including ventificated clasts, was most probably derived from reworking of Anglian tills which crop out both to the north and south of the NNR. Given this distribution pattern, Anglian tills may well have capped the Carstone surface to the east, and the bulk of this material may have been brought to the terrace by incremental mass movement or slope wash processes operating throughout periglacial times.

c) The valleys: At present the highly permeable bedrocks presumably allow rapid drainage of precipitation, there being little sign of any water in them now, apart from the occasional presence of patches of rushes. However, during the Devensian when, despite the lithology, the ground is likely to have been at least partly affected by permafrost, then infiltration would have been limited and surface flow much more likely, even if only seasonally during episodes of snow melt.

CONCLUSIONS

Whilst previous accounts of the geomorphology of this area have commented briefly on the possible origins of the scarp faces, here we speculate for the first time on the significance of the scarp-top benches. Despite the absence of definitive criteria by which cryoplanation terraces can be recognised, it seems at least plausible – as we have suggested – that cryoplanation offers a possible origin for these features. The presence of ventificated materials and a sand wedge indicate that active periglacial processes were operating in the area, whilst the actual morphology of the terrace is consistent with published accounts of other cryoplanation terraces. Finally, the dissection of the bench by streams, indicates it formed prior to the free availability of surface running water, an event which is most likely to have occurred when the post-glacial melting of ground ice occurred at the end of the Devensian. Subsequently podsolization of surface sand accumulations has taken place. The 'cliffs', rather than being shaped by either marine or lacustrine processes, are considered to have been most probably shaped by mass wasting processes.

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IRON PAN SEDIMENTS IN WEST NORFOLK: NEW SECTIONS AND SPECULATIONS REGARDING THEIR ORIGIN AS A BUILDING MATERIAL

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ABSTRACT

Three temporary sections in which iron pan deposits are present are described and located. Iron pan deposits used as building materials in West Norfolk may have been exploited opportunistically, during the digging of dykes, ditches and ponds. This hypothesis would explain the apparent lack of source excavations, of the type associated with more systematic extraction.

INTRODUCTION

Iron pan is an extremely variable material variants of which are united only in being well cemented by iron oxides, which generally gives it a dark brown colour. In West Norfolk this has often led to iron pan being confused by writers on architecture and building materials, (e.g. Pevsner 1962), with materials from the local lower Cretaceous Cartsone (Gallois 1994).

Most West Norfolk iron pan is, however, geologically much younger; this is in many cases obvious because of the inclusion in the material of clasts of flint, which have to be derived from the upper Cretaceous Chalk.

Iron pan is formed in a variety of sediments (often glaciofluvial sands and gravels) as a result of cementation within a zone of fluctuating water tables. It is, when freshly exposed, often so soft that it can be cut and shaped with a spade (Potter 1987), but subsequently hardens (or ‘seasons’ (Shadmon, 1996)) when allowed to dry out.

Iron pan has a variety of names, including gravel-stone, rubblestone, and ironstone (Robinson & Worrsam 1989), who presented a case for calling it ferricrete,

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a usage which has been followed by Hart (2000). According to Gary *et al.* (1972) this term was introduced by Lamplugh (1902) to describe a 'conglomerate consisting of surficial sands and gravel cemented into a hard mass by iron oxide derived by the oxidation of percolating solutions of iron salts'. As a secondary meaning they give a 'ferruginous duricrust', it is, presumably, this association with duricrusts – which form under tropical conditions – which has led Allen (2004) to suggest that the term ferricrete is 'unacceptable', and should be avoided.

Gallois (1994) refers to the West Norfolk iron pan as 'ferruginous pan' and notes that elsewhere in southern England it is known as 'chevick' or 'shrave', further noting that it generally occurs as lenticular beds or irregular concretionary masses.

Allen (2004) recognised the following main varieties of ironpan (his usage):

- ironbound conglomerate, with dominantly flint clasts
- ironbound pebbly sandstone
- ironbound sandstone, with grain sizes ranging from coarse to fine
- cinderstone
- brashy ironbound sandstone resembling a breccia

Whilst the first three of these appear straightforward, the last two are particularly distinctive and, presumably, owe their origin to very particular – but unknown – depositional or diagenetic conditions. Allen refrains from speculation as to their origins, other than observing (*op cit.* p.32) that occurrences of Cinderstone appear to be closely linked to the outcrop of the lower Cretaceous Leziate Sands (Gallois 1994), and that a white Leziate-like sand may occur in cavities within it.

He goes on (Allen, *op cit.* p. 30-34), to discuss possible sources of this material but comments on the '*elusiveness at the present day of the pits and quarries from which ironpan was procured*', further noting that they must once have been both '*numerous and scattered widely*'. This is illustrated in his figure 3.11 which shows the relative abundance of buildings in settlements in which iron pan is used.

Iron pan is fairly widely used as an ecclesiastical building material in West Norfolk (Allen 2004) and elsewhere (Potter 1987; Robinson & Worrsam 1989), although its use in domestic buildings is much more limited. Potter (1987) has pointed out that it has been used most frequently in areas such as the Thames basin where alternative building stones are in short supply. Its most substantial use as a building material seems to be associated with Saxon and Norman churches. In later buildings it occurs less frequently, mostly as small blocks, where it may have been

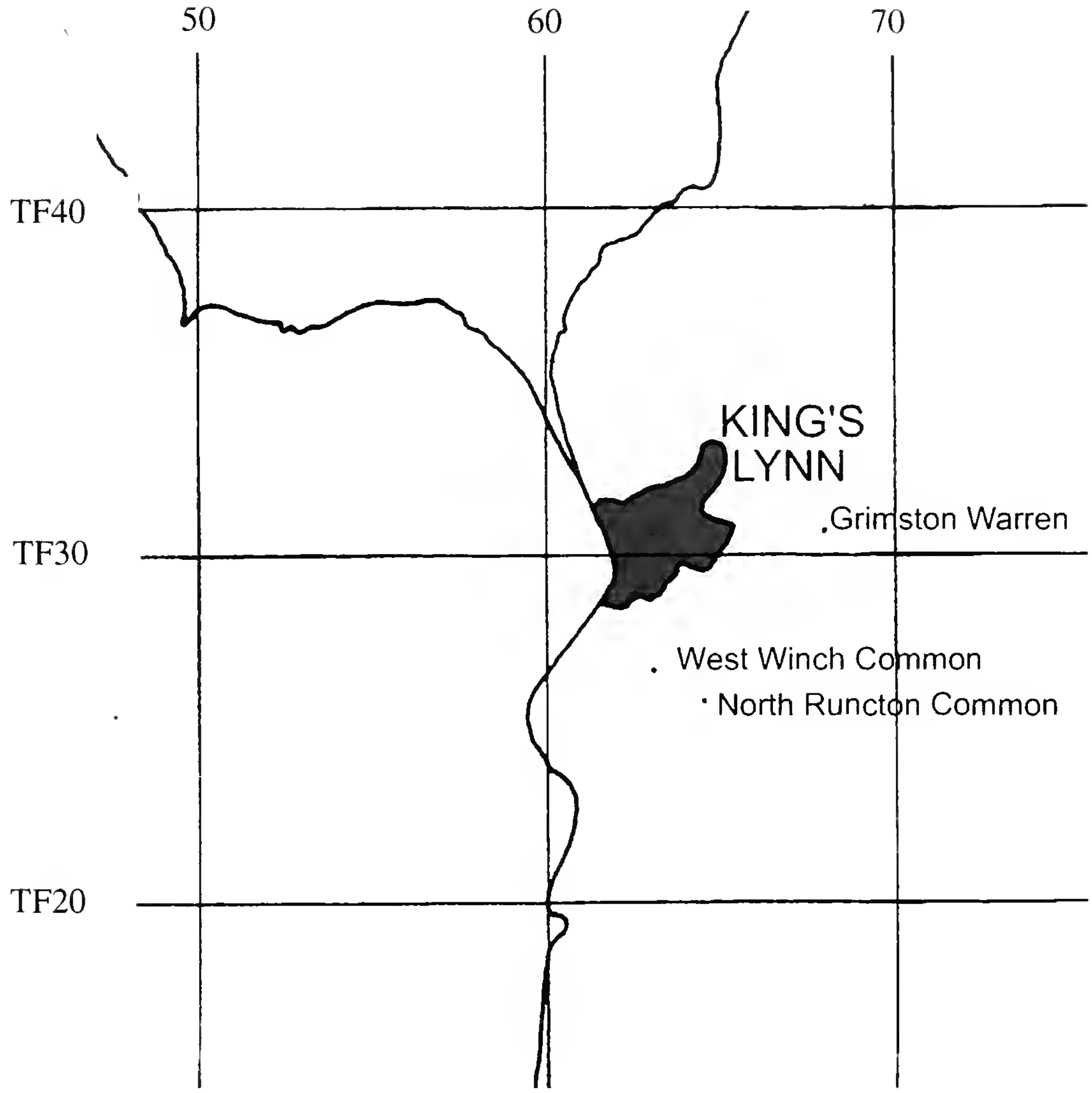

Fig. 1. The location of recent finds of *in-situ* iron pan. The marginal numbers refer to the 10 km squares of the Ordnance Survey grid; all are within the 100 km square TF.

recycled from earlier buildings, although in some instances it may have been newly obtained from local sources.

SECTION DESCRIPTIONS

Recent fieldwork has discovered three sites (Fig. 1) where iron pan is either present *in situ*, or lies near to probable local extraction sites.

1. Grimston Warren

Recent fieldwork in the Gaywood Valley located a floodplain site, at c. 5cm OD, just to the south of Grimston Warren (at TF67282102) where blocks of iron pan were lying by the side of a track (Fig. 2), adjacent to a couple of dykes. They were, presumably, extracted locally and then abandoned, presumably because there was no

use or demand for the material. Included amongst the debris were several large blocks of Silver Carr, a lithified facies of the Leziate Beds occurring in the Castle Rising area, which is also used locally as a building stone; these were presumably, field stones removed during ploughing or encountered during ditching operations.

2. West Winch Common

West Winch Common, at a height of c. 5 m OD, lies on the floodplain of the river Nar. It is bordered on its western edge by the Puny Drain, however, there are several drains which run roughly east-west across the common. These are, compared to the Puny Drain, shallow affairs which are evidently not as frequently or assiduously cleaned out by the Internal Drainage Board as is the Puny Drain.

Fig. 2. Block of iron pan, showing a pebbly sandstone facies. Clasts consist dominantly of angular flints. Scale is 20 cm.

One of these cross drains, running between TF62571658 (western end) and TF67791648 (eastern end), had (July 2012) obviously been cleaned out comparatively recently (Fig. 3). Unlike the other cross dykes it was free of scrubby vegetation, and was somewhat wider. The banks were, in places, covered by vegetation but elsewhere – where cattle poaching had occurred – the underlying sediments were exposed in the banks.

Iron pan was exposed at the eastern end of the dyke, on the north facing bank, over a distance of about 8 m (between TF62771648 and TF62761648), at a depth of 40 cm from the surface. The exposure was intermittent between these two points, and the maximum thickness exposed was around 50 cm. The material present consisted

Fig. 3. The West Winch Common locality, showing exposures on the left hand (southern) side of a shallow dyke.

of poorly sorted pebbly sandstone, the dominant clasts consisting of angular to sub-angular flints.

Iron pan material, of several different facies, is widely used in the parish church (St. Mary's, West Winch), particularly on the north side. A few fragments were also found in a garden wall facing the common (at TF62751596) although the bulk of the wall was made of lower Cretaceous Carstone.

3. North Runcton Common

Recent survey work in North Runcton located a large deep dyke which was cutting across the common (Fig. 4). Iron pan material was clearly exposed on the side of the dyke, occurring about 1 metre below the surface, and forming a layer about 1.5 metres thick. This iron pan is a pebbly sandstone, with angular flint clasts.

The site lies at a height of c. 16 m OD and the underlying bedrock is the sandy Mintlyn Member of the Lower Cretaceous Sandringham Sands Formation. According to the geological map of the area (BGS 1978) there are no superficial deposits in the area. However, as the Mintlyn Beds cannot contain flint fragments this assertion is questionable.

The ironstone pan was well exposed (apart from a covering of moss) on the southern, north facing slope; on the south facing slope (which is presumably more heavily weathered) it had broken down into a ferruginous sandy soil. Excavating the side, however, quickly established its presence.

There are also a couple of ponds on the common; their sides did not show any exposures of iron pan but it seems at least possible that it might have been present originally. Gallois (1994) noted the local use of iron pan deposits in barns and walls, especially in the North Runcton area. It has also been used in the east wall of the parish church and there are several houses in the village made of dressed iron pan, one of which is illustrated by Allen (*op cit.* plate 3.6 C). Gallois (1994) considered these materials to be particularly associated with the outcrop of the Mintlyn Beds (an argument which is not supported by the evidence presented by Allen, 2004). He then suggested that a pit at Manor Farm, North Runcton (at TF639157) was probably dug specifically for building materials, but that elsewhere it was dug out to prevent damage to ploughshares. The pit at Manor Farm is very shallow and barely visible at present.

Fig. 4. View of dyke on North Runcton Common (TF63921552), looking east. The best exposures of hard iron pan are on the southern (shaded) side of the dyke.

DISCUSSION

Land improvement for agriculture often involves drainage, and ditch digging, whilst the construction of ponds for watering stock also involves digging holes. It is therefore tempting to suggest that the *'elusiveness'* of pits and other sources for iron pan commented on by Allen (2004), is largely illusory; they are in plain sight but are linear or circular, and comparatively small in scale. Rather than extraction being a considered activity it may well have been opportunistic, occurring as and when ditching took place, or when ponds were being dug.

Once dug, ditches tend to be fairly permanent features only requiring fairly small-scale maintenance work, certainly not the levels of effort required when first being created. This may explain why iron pan is frequently found in the foundation layers of churches but is often less common, and consists of smaller blocks, at higher levels. The large blocks required for foundation stones may be contemporary with major episodes of land drainage, i.e. the digging of major dyke systems, whilst later maintenance ditching would only yield small fragments.

It is noticeable that many of the sites mapped by Allen (*op. cit.*), where iron pan is a dominant or common building material, lie close to the fen edge, i.e. in positions where early drainage work is likely to have taken place. The date of churches incorporating iron pan may record the relative timing of agricultural improvement and rising levels of wealth/status of settlements – in being able to afford a permanent church, whilst the proportion of iron pan present in a particular church may record the relative intensity of drainage activities locally.

Rackham (1986) discusses the history of Fen drainage, pointing out that following the initial efforts of the Romans, there was a Second Draining, in Anglo-Saxon times, followed by another phase in the early Middle Ages. The depth of excavation of dykes may also be a record of contemporary water levels and the need to drain land, or to provide water resources for stock. However, although later drainage efforts in the area are well documented (e.g. Parker & Pye 1976) it is inherently unlikely that drainage measures would have been specifically mentioned at such an early period. Although Silvester (1998, 1991) makes tantalisingly vague references to early drainage efforts, there appears to be nothing definite on record, and certainly nothing specifically linking land drainage and the extraction or use of iron pan.

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CONTENTS

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The illustration on the front cover is figure 4 from the article by Stevenson and Giles in this issue of the Bulletin. It shows the steep scarp face ('cliff') surmounted by a flat bench surface and is interpreted as a cryoplanation terrace. View from TF670284.

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